



# **Inventory & Monitoring Program**

## **Pacific Island Network**

### **Monitoring Plan**

## **Supporting Documents: War in the Pacific National Historical Park Resource Overview**

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### **Pacific Island Network (PACN)**

#### *Territory of Guam*

War in the Pacific National Historical Park (WAPA)

#### *Commonwealth of the Northern Mariana Islands*

American Memorial Park, Saipan (AMME)

#### *Territory of American Samoa*

National Park of American Samoa (NPSA)

#### *State of Hawaii*

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

## **EXECUTIVE SUMMARY AND INTRODUCTION**

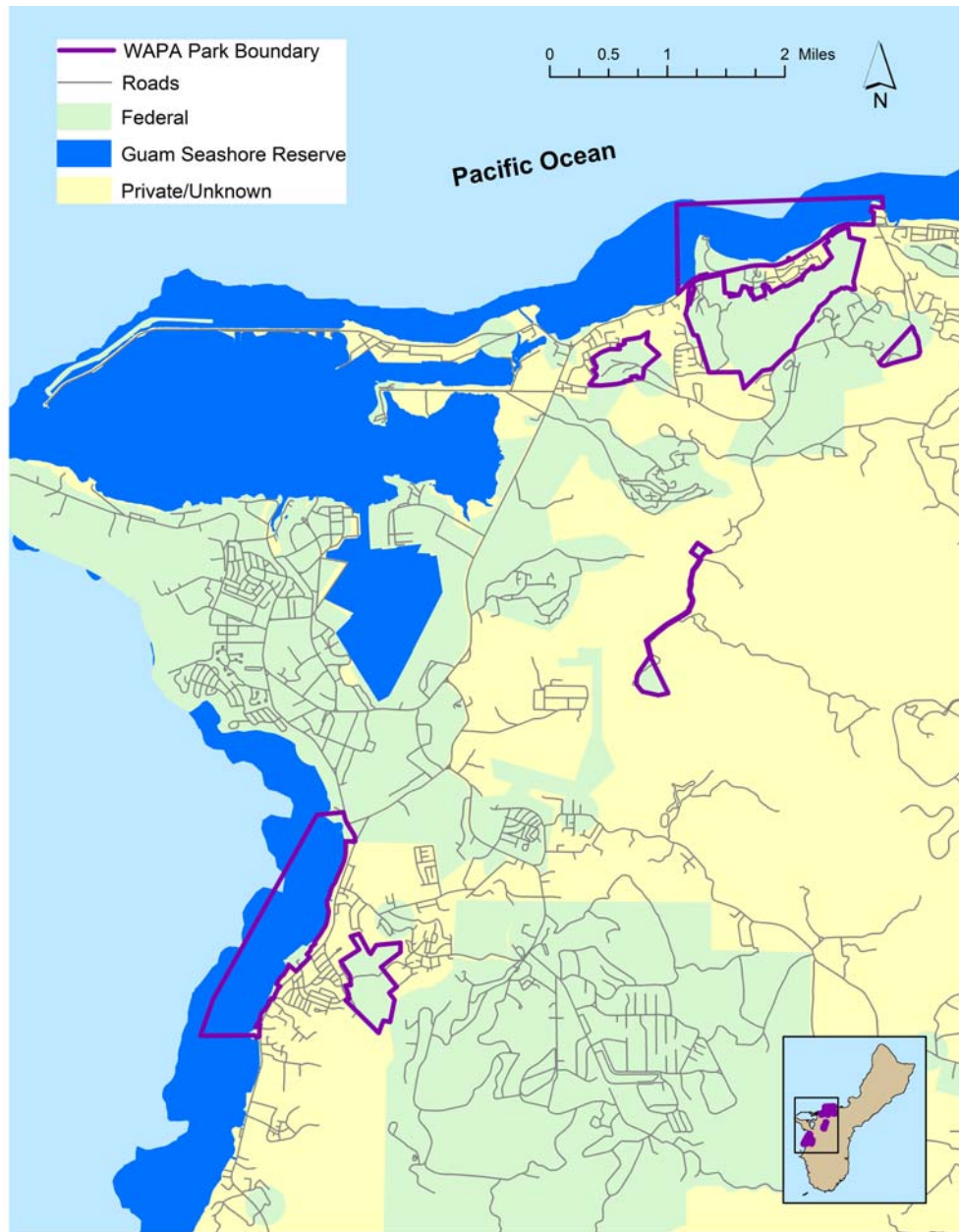
### **Enabling Legislation**

War in the Pacific National Historical Park (WAPA) was established (P.L. 95-348, section 6a) in 1978 “to commemorate the bravery and sacrifice of those participating in the campaigns of the Pacific theater of World War II [not only the United States and Japan, but includes Australia, Canada, China, France, Great Britain, the Netherlands, New Zealand, and the Soviet Union] and to conserve and interpret outstanding natural, scenic, and historic values and objects on the island of Guam for the benefit and enjoyment of present and future generations...” Included in WAPAs enabling mandate: other points on the island of Guam relevant to the park may be identified, established, and marked; interpretative activities will be conducted in the following three languages: English, Chamorro, and Japanese; and, the park may pursue berthing and interpretation of a naval vessel of World War II (WWII) vintage which shall be accessible to the public on the island of Guam. To the maximum extent feasible, the park is directed to employ and train residents of Guam or of the Northern Mariana Islands to develop, maintain, and administer the park; and, no fee or charge shall be imposed for entrance or admission.

To find enabling legislation documents on-line follow the “Policy & Legislation” link from the Pacific Island Network website ([www1.nature.nps.gov/im/units/pacn](http://www1.nature.nps.gov/im/units/pacn)).

### **Geographical and Political Setting**

Guam is the largest and southernmost of the 15 islands in the Mariana Islands chain, located in the western Pacific Ocean, 2419 km south of Tokyo and 6116 km west of Honolulu. Guam is an organized, unincorporated territory of the US with policy relations between Guam and the US under the jurisdiction of the US Department of the Interior, Office of Insular Affairs. The islands population is culturally diverse; in addition to the local Chamorro population, immigrants from mainland Asia, Japan, the Republic of the Philippines, and nearly all of the islands of the Federated States of Micronesia have settled in Guam since WWII. With an estimated population of approximately 160,000 people, the economy is dependent primarily upon tourism. Guam is 52 km long and 6 to 15 km wide. The island is of volcanic origin with basalt mountains rising more than 1000 feet in the south, a raised limestone plateau in the north, and surrounded by fringing coral reefs. The Park is located on the central west coast side of Guam and consists of seven discontinuous units important to 1944 invasion beaches and adjacent offshore lands, waters and inland areas (see map below). The units referred to in this summary include Asan Beach, Fonte Plateau, Asan Inland, Piti Guns, Mt. Chachao and Mt. Tenjo, Mt. Alifan, and Agat Beach; for a total of 1960 acres divided between terrestrial and marine environments. Adjacent land owners include both private land owners, as well as the US Navy, and the Government of Guam (see map on side). Protected areas on Guam include Anao Conservation Reserve, the Pati Point Natural Area, the Masso River Reservoir Area, the Guam National Wildlife Refuge, the Haputo Ecological Reserve, the Orote Peninsula Ecological Reserve Area and the Guam Territorial Seashore Park.



### **Significant Cultural & Natural Resources**

The park contains sites important to the 1944 invasion and recapture of Guam during WWII, and as a result, each unit contains some significant resources. The following are included on the National Register of Historic Places: Agat and Asan Invasion Beaches, Asan Ridge Battle Park, Hill 40, Matgue River Valley Battlefield, Memorial Beach Park, and Piti Coastal Defense Guns. In addition to cultural resources significant to WWII, there are sites of cultural importance to the island's Chamorro resident population with many of these having marine-related importance.

It is very difficult to document the exact appearance of park lands prior to WW II; however a general characterization may be possible. Approximately 1000 acres (over ½ of total park area) of marine environment is equally divided between two ocean units (Asan Beach and Agat Beach units) and contains significant marine resources. WAPA has extensive coral reef resources that are predominately fringing and extend up to 100 meters offshore. The Agat Unit also has extensive seagrass beds. Scattered across four units (Agat Inland, Mt. Alifan units, Mt. Tenjo, and Fonte Plateau) are 1,000 acres of tropical savanna, limestone and riverine forests. The remaining park unit, Piti Guns, is the site of an experimental forest and contains mahogany trees planted in the 1920s.

### **Resource Management Priorities**

As a historical park, conservation of resources in accord with the World War II setting is a top priority. Natural resource management objectives, highlighting terrestrial native vegetation, marine and freshwater resources include managing "...native terrestrial ecosystems in accord with those conditions just prior to the American re-invasion of Guam ..." and to "preserve and interpret important natural features such as native plant communities and stream and marine bed environments..." (WAPA Resource Management Plan 1997). WAPA is currently in the process of creating a Cultural Landscape Inventory and Management Plan that will provide guidance for terrestrial units. Management of marine areas is intended to conserve the resources in a natural state while allowing for traditional and cultural uses.

## NATURAL RESOURCES

### Focal Ecosystems and Processes

- Coral reefs
- Sea grass beds
- Offshore islets
- Wetlands
- Savanna grasslands and limestone forest remnants
- Geology
- Threatened & Endangered Species

**Coral reefs:** WAPA has extensive coral reef resources. Fringing reefs extend up to 100 meters offshore before dropping quickly to depths of 25-30 meters. Reef slopes are coral covered. Several ephemeral and permanent streams incise the reef flats and provide varied microhabitats. Many of the species on the reef occur nowhere else in the National Park System and make this a unique natural resource. In the Mariana Islands (including Guam) there are 119 known species of non-scleractinian corals (Paulay et al. 2003), 377 species of scleractinian corals (Randall 2003), 26 species of hydrozoan coral (Randall 2003) and 1019 shore fishes (Myers and Donaldson 2003); with some of these species having been documented in the park units. Coral recruitment is an important process to monitor as it is integral for perpetuation of a reef. Furthermore, coral reefs can act as indicators for local and global climate change, an important facet of air quality.

**Seagrass Beds:** Extensive sea grass beds, comprised mostly of *Enhalus acoroides*, but containing all three species found in Guam, line the nearshore shallow sand of the Agat Unit. Other than within areas adjacent to AMME these seagrass beds occur nowhere else in the PACN. Seagrass beds may serve as a nursery habitat for coral reef organisms, provide shelter and habitat for neretic organisms, and can influence water quality.

**Offshore Islets:** WAPA has six small offshore islands that are among the last remaining land areas in Guam free of *Boiga irregularis* (brown tree snake). These islets are a refuge for numerous sea birds and several endemic species of lizard.

**Wetlands:** There are several small coastal wetland areas and forested wetlands and bogs in the inland areas of WAPA. The Guam Coastal Management Program designated an area in the Apaca Point area of the Agat Unit as a part of the Namo River floodplain wetland. These wetlands may be home to a diverse faunal assemblage.

**Savanna Grasslands:** Native savanna grassland ecosystems found primarily on sloped hillsides in southern Guam, are present in the western slopes of the Asan Inland Unit and is a major component of the Mt. Alifan and Mt. Tenjo-Mt. Chachao Units. They are comprised of native sword grass, other low-lying shrubs and scattered with patches of forest. Common plants found in this type of savanna include: *Pandanus tectorius*, *P. dubuis*, *Hibiscus tiliaceus*, *Ficus prolixa*, *Glochidion mariannensis*, and *Premna serratifolia* (Mueller-Dombois & Fosberg 1998, Raulerson 1970). *Leucaena*

*leucocephala* (tangantangan) was introduced after World War II to curb erosion and now grows in locally dense thickets.

***Limestone Forest Remnants:*** Limestone forest, usually found in northern Guam on exposed limestone is a mosaic of different community subtypes. On the ledge of the Fonte Plateau Unit there is a limestone forested area with native vegetation extending down the north facing slope.

***Terrestrial Invertebrate Diversity:*** Gressitt (1954) estimated, at the time, Guam to have 2000 species of insects, with 45% of these believed to be endemic. The native vegetation communities (limestone forest, savanna, and riverine forests) may harbor rare terrestrial invertebrate species not found in other disturbed areas in the more populated areas of Guam. There are three species of *Partula* (land snail family) known to exist on Guam and in a recent survey (Hopper 1992) *Partula radiolata* and the listed candidate species *Samoana fragilis* were found within or adjacent to WAPA.

***Geology:*** “The Mariana Islands are a classic example of an island arc – a curved line of stratovolcanoes that rise up from the ocean floor. The islands owe their origin to subduction, the tectonic process that thrusts one plate beneath the other. Volcanic activity initiated the growth of the islands between 10-45 million years ago. Much of the island is characterized by its karst topography. The island has two basic geologic compositions: in the central and northern portion is a relatively flat, raised coralline limestone plateau, sections of which are steep coastal cliffs. The southern portion is a mix of high volcanic hills and valleys composed of pillow basalts, basalt flows and volcanic derived sedimentary rocks interfingering with limestone. The limestone is exposed on the islands due to uplift associated with the subduction of the Pacific plate.” (excerpt from the Geology Workgroup Report, PACN)

***Threatened & Endangered Species:*** *Chelonia mydas* (green sea turtle) and *Eretmochelys imbricata* (Hawksbill sea turtle), both listed as endangered in Guam, have been observed in park waters, but no nesting has been recorded. Turtles are probably transient and may be feeding in extensive seagrass and algal beds, especially in the Agat Unit. *Eretmochelys imbricata* have been observed by park staff feeding at depth in the Asan Unit.

*Pteropus tokudae* (Mariana fruit bat, fanihi in Chamorro), traditionally a local delicacy have been hunted to the brink of extinction and can be found in a colony on the northern end of Guam. It is also believed that this species might forage in the park.

It is not known if the endemic species, *Halcyon cinnamomina cinnamomina* (Micronesian kingfisher, sihek), is found within the park. This endangered species is thought to exist only in captivity. Proposed critical habitat might extend into the Mt. Alifan unit of the park.

The candidate endangered butterfly, *Hypolimnas octucula mariannensis*, has been found in the park and it is not known if two other native insects occurred in the park but it is

believed they may be extinct, *Vagrans egestina* and *Neptis guamensis*. The listed candidate species *Samoana fragilis* has also been observed in the park.

### **Threats & Stressors**

- Overfishing
- Sedimentation
- Savanna Wildfires
- Pollution, Contaminants and Ordinance
- Adjacent Land Use
- Air Quality & Climate
- Invasive and Alien species

**Overfishing:** According to WAPA's agreement with the territorial government, the park must allow access for traditional subsistence fishing in accordance with territorial laws. Fishing is conducted for a wide variety of species, ranging from fish to invertebrates to algae. Because of the park's proximity to population centers and ease of access to the ocean, fishing pressure in both the Agat and Asan Beach units is among the highest on the entire island. Observations made by park staff suggest the intensive fishing, which has been estimated at 30,000 fisherman-days per year, is having a noticeable effect on the nearshore environment. In addition to having direct impacts on target fishery species, fishing is also contributing to debris, predominantly lost gear and tackle, and to reef trampling. Ecological impacts of fisheries are not known. In order to address this question, baseline fisheries studies are currently underway and include estimating fishing effort and pressure within the park as well as fishery population estimates and fish movement.

**Sedimentation:** Sedimentation has been identified as the most significant threat to Guam's coral reefs. No baseline data exists for sedimentation rates into park marine waters, but park staff routinely observes high sediment conditions in waters of both the Agat and Asan units. Work is currently underway to gather baseline sedimentation data for the park (see below in monitoring section).

**Savanna Wildfires:** Wildfires are common throughout Guam and have a high frequency of occurrence within the savanna grasslands of WAPA. The practice of upland burning of vegetation has led to increased erosion and high sediment loads in streams. The resulting run-off of sediment negatively impacts the coral reefs by smothering them and by lowering water quality.

**Pollution, Contaminants and Ordinance:** Contaminant levels within the park are unknown but past activity in the region suggests that chemical and heavy metal contaminants may be present. PCBs were found in fish tissues just north of the Agat unit in 2002, but EPA testing conducted at the park boundary found no PCBs. An extensive ammunition dump off Camel Rock (reportedly with 64 tons of unexploded munitions) is within the park's boundary. Metal from relic equipment can have localized but significant ecological effects on the community. For example, iron enrichment can

sometimes stimulate rapid growth of some blue green algae that can overgrow and kill surrounding coral and other sessile organisms. The Hagatña Sewage Treatment Facility is upstream from the park boundary and was severely damaged during Typhoon Pongsona, but it is still in operation. Up until recently (2001), the Agat Sewage Treatment Facility dumped effluent directly within the Agat unit of WAPA. This facility has been closed and the effluent from this facility is now released through a deepwater outfall to the north of the Agat unit.

**Adjacent Land Use:** Guam zoning regulations are poorly enforced, and human development comes to the very edge of the park boundary. Guam also does not have an approved Coastal Zone Management Plan, so regulations overseeing development along the coast are not complete. The primary north-south road on the island runs directly adjacent to park waters, often only a few meters from the water's edge. Several buildings have been constructed along the coast, and many abut directly on the water, built out on the seaward edge on sea walls. Development in the watersheds above both the Asan and Agat Beach units is considerable and anti-erosion regulations are inconsistently enforced by the local regulatory agency during construction.

**Air Quality & Climate:** Air Quality and Climatic related stressors potentially influencing WAPA include climate change, sea surface temperatures rising, increase in UV and increase in storm frequency and occurrence. Typhoons are a constant periodic and natural stressor to Guam's marine and terrestrial environment. Typhoons that have passed over or near WAPA since 2000 include Saomai (2000), Chata'an (2001), Halong (2001), Pongsoña (2001), Tingting (2003), Chaba (2003), and Songda (2003).

**Invasive and Alien Species:** The only documented large invasive mammals in WAPA are *Cervus mariannus* (Philippine deer), feral pigs and feral cats and dogs. To date there have been no studies examining their densities and impacts. Other invasive animals that have been observed in the park include *Bufo marianus* (marine toad), *Achatina fulica* (Giant African slug), *Carlia fusca* (curious skink), and *Boiga irregularis*.

Many native birds have become extinct or endangered because of the brown tree snake (*Boiga irregularis*) (Savidge 1987, Engbring and Fritz 1988). Of WAPA's native forest birds, only the Guam swiftlet (*Aerodramus bartschi*) may be extant, the remainder are believed to be extinct. At the height of its invasion, *B. irregularis* numbered 12,000 snakes per square mile.

One of the most invasive plant species is *Leucaena leucocephala*, introduced to prevent erosion after the events of World War II. It has spread extensively, particularly on limestone soil. Another alien plant and potential threat is the mission grass that prevents re-establishment of the native savanna vegetation.

The WAPA marine units have not had a comprehensive baseline inventory for the presence or absence of alien or invasive marine species; thus the potential for these ecologically and economically destructive species to be present in the park is high.



### **Water Quality Designations**

Guam Environmental Protection Agency (GEPA) also has a classification system for water bodies based on “Designated Uses” and “Use Support Criteria” which amount to water quality standards. Marine waters are classified as M-1, M-2, or M-3, and freshwater as S-1, S-2, and S-3. Within NPS boundaries, marine waters are classified as M-2. This classification means that the waters are of “Good” quality, and the “Primary Designated Uses” are whole-body contact recreation, aquatic life protection and consumption. Inland waters for this park have been designated S-3 indicating the lowest quality for this resource. The Northern Guam Lens aquifer has been listed as impaired as of the 2004 GEPA CWA 303(d) report, although, the non-potable perimeter of the aquifer has been classified as G2 due to its increased salinity.

### **CULTURAL ISSUES**

- World War II
- Chamorro Culture

**World War II:** In the legislative mandate establishing this park, resources specifically and intentionally include “values and objects.” By definition, ‘values’ include non-physical resources such as memories of the Pacific war, cultural attitudes and cultural traditions (WAPA 1988 Statement for Management). The park units consist of those areas significant to the 1944 invasion and recapture of Guam during WWII. In particular, “concentration” of resources exist at Gaan Point in the Agat Unit, and Asan Ridge. Some of these resources are dangerous (unexploded ordinance) or fragile, and could be affected by invasive plant species.

**Chamorro Culture:** Prewar settings are difficult to ascertain, but long-time residents contributed to knowledge, including important traditional Chamorro sites within the park. Significant areas (within WAPA units) important to the Chamorro culture are primarily marine-based. The Asan Beach unit was an area used to gather food from the reef flat. The Agat area was also used for subsistence-based fishing. Some legends are associated with Camel Rock in the Asan unit and the islets in the Agat unit. Prehistoric pottery was found in the Mt. Alifan Unit.

### **MANAGEMENT ISSUES**

#### **Park Management**

A general management plan and Environmental Impact Statement were finalized in 1983 as well as a Natural Resource Management Plan in 1997. “Although no specific resources are mentioned in the act creating the park, the nature of the areas included within the park’s congressionally established boundaries clearly mandate the conservation and interpretation of historic resources relating to Guam during World War II.” While the park is primarily a historic park commemorating the “bravery and

sacrifice made by all Pacific Island residents” during World War II, primary park resources are identified as those that have “natural, scenic, and historical values and objects... and to be conserved and interpreted. (WAPA Statement for Management 1988).”

In regard to cultural resources management objectives are to “stabilize and preserve the sites and features related to the American reinvasion of Guam. Develop interpretive programs related to the Pacific encounters of World War II. (WAPA Natural Resource Management Plan 1997).”

In regard to natural resource management, objectives are to “Manage native terrestrial ecosystems generally in accord with those conditions just prior to the American re-invasion of Guam. In many instances vegetation will be used which appears similar in life-form to the 1944 vegetation, i.e., grass instead of rice paddies. Preserve and manage important geographical and historical features within the park in order to provide a setting with sufficient historical integrity to adequately interpret the battle for Guam as an example of the island-by-island fighting in the Pacific war battles. Preserve and interpret important natural features such as native plant communities and stream and marine bed environments for public use and enjoyment (WAPA Natural Resource Management Plan 1997).”

Park management documents (General Management Plan, Resource Management Plan, etc.) are available on-line at the NPS intranet site ([www1.nrintra.nps.gov/im/units/pacn/parks/mgmt\\_docs.htm](http://www1.nrintra.nps.gov/im/units/pacn/parks/mgmt_docs.htm)). This website is available only from NPS computer networks. Inquiries about public access should be directed to the park.

***Fishing:*** Approximately one third of the submerged lands within WAPA are owned by the NPS; the remaining lands are owned by the Territory of Guam, which, through an MOU with NPS relinquished administrative control of these lands to WAPA. A condition of the MOU guarantees the continuation of traditional subsistence fishing within the park in accordance with territorial fishing regulations. The broad definition of "traditional" fishing used by the Government of Guam also adds further complexities. Proximity to large population centers and easy access have made the Agat and Asan marine units popular sites for fishing and recreation. The quantity of harvested fish and other marine life is poorly known. Observations made by park staff suggest the intensive fishing, which has been estimated at 30,000 fisherman-days per year, is having a noticeable effect on the nearshore environment. It is also suspected that commercial fisheries are occurring in the park waters. Knowledge of extraction rates would help to better manage fisheries within the park waters.

***Adjacent Land Use:*** Adjacent land use, in the form of light industrial, commercial and residential development encroaches and poses as potential threat to park lands and waters. Guam has very poorly enforced zoning regulations, and human development comes to the very edge of the park boundary, and in some cases has crossed onto park lands. Guam also does not have an approved Coastal Zone Management Plan, so

regulations overseeing development along the coast are not complete. The primary north-south road on the island runs adjacent to park waters. Several buildings have been constructed along the coast, and many directly abut the ocean. Development in the watersheds above both the Asan and Agat Beach units is considerable and anti-erosion regulations are inconsistently enforced by local regulatory agencies during construction.

***Erosion & Sedimentation:*** One of the greatest threats to the health and survival of Guam's coral reefs are sediment loads carried by streams and rivers. Sediment can harm coral reefs by either smothering them or by decreasing light availability needed for zooxanthellae (symbiont that sequester energy) to photosynthesize. Sedimentation accumulates on WAPA's coral reefs from several sources, relating primarily to poor land management practices. Those sources can include wildfires and urban development. Wildfires are intentional, resulting from human activities relating to agriculture, the facilitation of hunting pigs and deer, and arson. Fires do not occur naturally in high frequencies; therefore the native vegetation is not adapted to these rates of burning. After the fire, soil bare of anchoring vegetation is readily washed into rivers and streams and eventually to the nearshore environment. Within the park, up to 20% of the terrain is burned each year, constituting a major threat, stressor and land management issue.

## INVENTORIES

### **Existing, Completed Inventories**

***Marine Communities – Fish:*** Gawel (1977) conducted an inventory of fish species in Guam, including locations within the Agat Unit. Amesbury (1999) conducted a biological survey of both the Agat and Asan units, including a survey of marine fish. He found a total of 193 species in both units. Park staff continually update species lists and the most recent database has 255 known species for the park (WAPA Natural Resource Management).

***Marine Communities – Invertebrates:*** Portions of the Agat Unit were included with comprehensive invertebrate surveys (with separate macroinvertebrate and coral surveys) of Guam's coral reefs conducted by the University of Guam Marine Laboratory (see Randall 1978, Eldredge et al. 1977 below). More recently, Amesbury (1999) conducted a biological survey of both marine units, finding 191 species of macroinvertebrates and 57 species of coral.

***Marine Communities – Plants:*** Tsuda (1977) surveyed part of the Agat unit in a study on benthic algae. Amesbury (1999) conducted a biological survey of the Agat and Asan units, including a study on algae. He documented a total of 34 species of marine plants. *Amphiroa*, *Haalimeda*, *Neomeris*, and *Padina* were the most commonly observed algal species present, covering up to 75% of the available area. The distribution of seagrass and invasive marine algae by University of Hawaii and WAPA NPS ecologists is scheduled for FY05.

**Terrestrial Vertebrates – Reptiles:** Thorough inventories have been conducted for park reptile species (Rodda and Dean-Bradley 2001, Perry et al. 1998). Perry et al. (1998) inventoried the reptile species observed on offshore islets. Rodda and Dean-Bradley (2001) inventoried reptile species in the terrestrial park units. They conducted mark-recapture studies on *Boiga irregularis* during a 33 day period and found them to occur at low densities (7-20/hectare) relative to other areas on Guam (29/hectare). *B. irregularis* was harder to catch in areas with high occurrences of mice and rats (Asan upland unit) and might constitute a difficulty for control in these areas. They also collected samples of lizard abundance on grassland and *Leucaena leucocephala*. Lizard biomasses they collected included those for *Gehyra mutilate*, *Hemidactylus frenatus*, *Lepidodactylus lugubris*, *Carlia fusca*, and *Anolis carolinensis*. They found geckos to be less abundant in grassland plots, however in the *Leucaena leucocephala* plots they were almost half the lizard biomass. And, more recently introduced species (*C. fusca* and *A. carolinensis*) comprised 84% of grassland lizard biomass. In WAPA *Leucaena leucocephala* they comprised 38% of the biomass; whereas in other areas of *Leucaena leucocephala* on Guam they make between 56-65% of the lizard biomass.

**Freshwater Communities – Streams:** The USGS and NPS recently completed an island-wide inventory and map of streams in the upland units. They hiked to the major streams located in the Agat and Asan park units, including the Asan River and the southern fork of the Togcha River (in Agat). Information that they collected included streambed morphology, erosion patterns, bedrock composition, stream flow rates, fauna, and human alterations. General observations included significant erosion and garbage present in park streams. They also found a diverse freshwater community and some waterfalls present. They are in the process of writing a USGS open-file report which should include locations available in a GIS layer.

**Vegetation:** Plant inventories of the WAPA units have been recently been completed and a report forthcoming. Hopefully this recent inventory will provide more information on vegetation types found in the park as well as presence of rare plant species.

Rodda and Dean-Bradley (2001) sampled vegetation composition for plots where their traps were set during an inventory of reptiles at WAPA. They sampled both *Leucaena leucocephala* and grassland areas. They found that the *Leucaena leucocephala* in the Agat unit were fewer and larger whereas the Piti site had a higher species diversity. Grassland sites were comprised of different species than the *Leucaena leucocephala* sites. They also had no large trees with lower species diversity. Canopy height was lower in grassland sites with less vegetative biomass. Grasslands had both higher herb cover and species diversity but with less light reaching the forest floor.

**Terrestrial Invertebrates:** Mt. Alifan was surveyed in 2001 by Barry Smith for the presence and confirmation of the suspected extinction of *Partula salifana*.

### **Priorities for New Inventories**

**Marine Communities:** WAPA is lacking recent, formal inventories for many of its natural resources, and in particular for marine invertebrates, marine algae, and invasive species. There has been very limited work conducted on marine algae in Guam and recent inventories are needed, particularly with the potential for invasion by alien species and based on their resulting impact on Hawaiian nearshore reefs and beaches. A baseline inventory of marine invertebrates is also needed.

**Freshwater Communities – Streams:** Now that stream location and physical characterization are known for WAPA, inventory of faunal communities are needed.

**Freshwater Communities – Wetlands:** Recent inventories were conducted on terrestrial vegetation, however, little is known on the community composition of wetland species, both plant and animal in the park.

**Terrestrial Invertebrates:** Large areas of vegetation in WAPA consist of invasive species. The presence of invasive vegetation and faunal species (e.g. deer and ants) contribute to indirect or direct loss of native species (e.g. butterflies). The last major insect survey was in the 1950s (Gressitt 1954) and focused primarily on agricultural pests. General surveys of insects are needed for Guam, and in particular surveys for snails (*Partula* and *Samoana*) butterflies, and insects.

### **Buffer Zone Inventories**

**Marine Landscape:** Randall and Holomon (1974) conducted a coastal assessment of Guam's shoreline from the 60' contour depth to the first major landform change after the beach area. Included in this study was a description of the structural elements of the following: major vegetation zones, rivers, estuaries, bays, beaches, rocky coastlines, reef zones, water masses and circulation patterns, climatic zones, geology and soil types, development areas and use patterns, and areas with rare or unique animals and plants.

The ACOE (1980) conducted a shoreline inventory of Guam describing physical characteristics, emphasizing shoreline erosion problems. They describe the physical characteristics of the shoreline and backshore area, qualitative analysis of coastal processes, and descriptions of fringing reef characteristics.

The University of Guam Marine Laboratory, for the Guam Coastal Management Program conducted baseline studies on mapping Guam's coastal region, mapping beaching, rocky shorelines, mangroves, river estuaries, and general distribution of corals, seagrasses, and sediments on reef-flat platforms (Randall and Eldredge 1976, Wilder 1977). Randall (1978) conducted more regionalized studies with baseline information for Fouha, Agat, Agana and Tumon Bays. They collected data on the quantitative distribution and community structure of benthic organisms, including coral, algae and macroinvertebrates.

**Marine Communities:** The Agat Unit was a part of an environmental impact study of Agat Bay during 1975-76 by the University of Guam Marine Laboratory (Eldredge et al. 1977). The survey included a catalog of marine organisms at Agat Bay, ocean current

study and potential impact from development. Cataloging included studies conducted on invertebrates (Eldredge 1977), corals (Randall 1977), gastropods and bivalves (Dickinson and Moras 1977), opisthobranchs (Carlson and Hoff 1977), fish (Gawel 1977), and marine plants (Tsuda 1977).

In part of an effort to gather baseline information on Guam's reef biological communities, the Office of Coastal Zone Management contracted the University of Guam to conduct studies on biological communities. Amesbury (1978) conducted a study on the nearshore fishes on species composition, abundance, distribution and environmental factor influencing these. Transect locations included two in Tumon Bay, two in East Agana Bay; both north of the Asan Unit. On the East coast side 4 transects were in Fouha Bay. And on the southwest coast 2 in Ylig Bay. Of the two sites that were located in Agat Bay, one was immediately within park boundaries (at the cemetery) and the other was at Rizal Beach just immediately on the north end of the Agat Boundary. For the transect located within the park boundary, there were 21 species observed on the inner reef flat and 14 observed on the outer reef flat during a survey May 24, 1977. A later survey on December 15, 1977 yielded less species observed 15 and 3 for inner and outer reef flats, respectively.

Also, as a part of the biological study of Guam's reef community, Randall, ed. (1978) contributed baseline information on marine plants, corals, and other macroinvertebrates. Surveys were conducted in the same bay locations. For marine plants, both species composition and percent cover was obtained at two times of the year. The number of species of marine plants observed in the site located within the park at Agat Bay was 38 (46 for the Bay). Coral distribution, size distribution, growth form distribution, and vertical profiles were found for two transects within the park at Gaan Pt. and just north of the Togcha River. Macroinvertebrates were also surveyed at the same locations as the coral, and in transects located within the Agat Unit, 12 species were observed.

Eldredge (1979) compiled information on both the Agat and Asan units, with information on the physiography, biotic resources, and recreation activity in a report to the National Park Service. Information on the Agat unit was drawn from Eldredge et al. (1977). Information for the Asan unit was drawn from Chernin et al. (1977) and from known observations.

## MONITORING

### **Previous & Existing Monitoring**

***Sedimentation:*** Monitoring of natural resources in WAPA is almost non-existent. Currently, studies are underway to establish baseline conditions. NPS is conducting baseline studies to document sedimentation (rates and composition) on the island's coral reefs. Other data currently collected includes water temperature and Photosynthetically Active Radiation (PAR). Studies on coral recruitment and percent cover are underway.

**Erosion:** Along with the University of Guam, WAPA is monitoring erosion rates in burned and non-burned plots. They are trying to gain a better understanding of the effects of wildfire on tropical savanna grasslands so the park can establish best management practices for reducing erosion. This monitoring program addresses some of the land-based effects on coral reefs and is paired with the above monitoring program on sedimentation.

**Marine Communities – Plants:** Development of monitoring protocol for seagrass and assessment of alien algae will commence August 2005 by the University of Hawaii and NPS ecologists.

**Marine Communities – Fisheries:** Guam's Division of Aquatic and Wildlife Resources is monitoring the effectiveness of marine preserves on fisheries targeted populations. A control unit for the study includes waters within the WAPA boundary.

**Freshwater Communities – Streamflow:** USGS Water Resources Division maintains streamflow-gauging stations at Asan and Namo Rivers that measure peak flows and stages associated with rain events. They also maintain a climate station at Mt. Chachao. A hydrologic reconnaissance of streams within WAPA was recently completed in 2004 and a report is forthcoming (described above). This study encompasses basic field operation and description of stream biology and hydrology with recommendations for stream gauge monitoring stations.

### **Priorities for New Monitoring**

**Marine Communities:** Focal fish species are not well known for in the marine environment at Agat and Asan, and should be studied further to determine species to monitor.

**Air Quality:** Basic meteorological measurements and solar radiation, particularly PAR, are needed for WAPA as there are currently none monitored.

**Water Quality:** Continued and additional water quality monitoring is important for both marine and freshwater resources.

### **Buffer Zone Monitoring**

**Fisheries Effort:** The Government of Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) is conducting fisheries stock assessment surveys to determine the effects of marine preserves on fish populations. The Asan fore reef slope (in the park) serves as a control site for the study. This study site overlaps with two of the sediment monitoring sites.

**Water Quality – WERI:** The University of Guam, Water and Energy Resources Institute (WERI – <http://www.uog.edu/weri>) monitors surface and ground water quality, pesticide

and heavy metal contamination, and soil runoff. They also analyze duplicate samples from the Navy's remediation program for the Orote Peninsula.

**Water Quality – GEPA:** Guam Environmental Protection Agency (GEPA – <http://www.guamepa.govguam.net/programs/index.html> ), as a part of its Monitoring Strategy for the Territory of Guam monitors *Enterococci* weekly at recreational beaches and surface water regularly. Three sample locations are adjacent to WAPA units. One site is just north of the Asan Unit and the other two are to the North and South of the Agat Unit.

Surface water monitoring occurs near streams and bays and includes the following "conventionals": pH, total suspended solids, total dissolved solids, temperature, turbidity, Nitrite-nitrogen, dissolved oxygen, salinity, total phosphorus, and ortho-phosphorus.

Additionally, GEPA is developing a biological monitoring program “Freshwater Periphyton and Benthic Macroinvertebrates Assessment Program.” They assess the periphyton and benthic macroinvertebrate freshwater assemblages and assess the levels of major chemicals of potential environmental concern (CPEC) in both sediment and tissue samples of recreational, commercial, and subsistence target species.

**Water Quality – Navy Environmental:** Navy Environment monitors water quality at 11 wells with the closest sites located near the Naval Hospital as well as the Almagosa Springs.

The area south of the Orote Peninsula is monitored by the US Navy as part of remediation for the Orote dump. This monitoring program includes analysis of water, invertebrates and fish for PCBs, heavy metals, dioxins, ferro-cyanins, and chlorinated pesticides. The area is currently open to recreational swimming but is closed for fishing.

**Sea Turtle Monitoring – DAWR:** DAWR is trying to determine Guam's sea turtle nesting populations and determine sea turtle nesting habitat type. They are using satellite telemetry as well as monitoring known nesting beaches.

**Brown Tree Snake Monitoring – USGS:** The USGS along with other organizations are trying to prevent the brown tree snake from expanding its range and establishing itself in new areas. They are using visual and trapping methods (including scent by Jack Russell Terriers) to capture snakes to prevent them from spreading to other islands or near habitats designated for endangered or threatened species.

## CONCLUSIONS

Designated as a historical park, terrestrial systems are to be managed in accord with conditions during the World War II time period (explicitly preserving features such as native plant communities and streams), while management of marine areas is intended to conserve the resources in a natural state. Natural resources include coral reefs, seagrass beds, sandy beaches,



wetlands and streams, tropical savanna, limestone, and riverine forests, karst caves, and offshore islets. Primary threats to resources include high fishing pressure, sedimentation, wildfires, increasing urbanization, invasive species, and chemical water and soil contamination. Future conservation efforts seek to provide baseline information in order to make management-based decisions that minimize impact of these threats. Many of these efforts will require working in partnerships other local and federal agencies and organizations.

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